Ultrasonographic Estimation of Age-Dependent Changes in Length of Spleen and Hepatic Lobes and Diameters of Portal Vein and Common Bile Duct in Children

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Abstract: Objectives: To estimate portal vein diameter (PVD) and common bile duct diameter (CBDD) and the length of spleen and hepatic lobes using abdominal ultrasonography (US) and to evaluate their relation to age, gender, weight (Wt) and height (Ht) of normal children younger than 18 years. **Subjects & Methods**: The study included 120 healthy children and adolescents younger than 18 years divided into 3 equal age groups with equal distribution of both sexes: Group A included participants <6 years old, Group B included participants aged 6-12 years and those >12 years were included in group C. All study participants underwent anthropometric and US measurements. **Results**: All obtained US measurements showed non-significant ($p>0.05$) difference between males and females. There was progressive significantly ($p<0.001$) higher measurements with advance of age in all obtained measurements All obtained US measurements showed a positive significant correlation with age, weight and height. However, PVD and spleen length showed their highest correlation coefficient with height, while CBDD and hepatic lobes' length showed their highest correlation coefficient with age. Receiver operating characteristic (ROC) curve analysis of age, weight and height as predictor for US measurements of internal organs defined height as the most specific predictor for PVD and spleen length with area under curve (AUC) = 0.697 and 0.550, respectively, weight as the most specific predictor for length of hepatic lobes with AUC=0.593 and 0.542, respectively and age as the most specific predictor for CBDD with AUC= 0.599. **Conclusion**: Age was found to be the main determinant of growth rate of these organs; body height was the most significant determinant for PVD and splenic length, while weight was the most significant determinant of CBDD and hepatic length.

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Keywords: Ultrasonography, Internal organs dimensions, Anthropometric measurements

1. Introduction

The liver possesses three surfaces, viz., superior, inferior and posterior. The liver has two main lobes; the right lobe (*lobus hepatis dexter*) is the larger and occupies the right hypochondrium. The right lobe is separated from the left lobe on its upper surface by the falciform ligament; on it's under and posterior surfaces by the left sagittal fossa; and in front by the umbilical notch. The left lobe (*lobus hepatis sinister*) is the smaller and is situated in the epigastric and left hypochondriac regions. Its upper surface is slightly convex and is molded on to the diaphragm; it's under surface presents the gastric impression and omental tuberosity **(Chaib et al., 2005; Chaib et al., 2007)**.

Common Bile Duct (*ductus choledochus*) is formed by the junction of the cystic and hepatic ducts; it is about 7.5 cm. long, and of the diameter of a goose-quill. It descends along the right border of the lesser omentum behind the superior portion of the duodenum, in front of the portal vein, and to the right of the hepatic artery; it then runs in a groove near the right border of the posterior surface of the head of the pancreas; here it is situated in front of the inferior vena cava **(Castaing, 2008; Strong et al., 2013; Chaib et al., 2013)**.

The hepatic artery and portal vein, accompanied by numerous nerves, ascend to the porta, between the layers of the lesser omentum. Then, the portal vein runs through the portal canals enclosed in Glisson's capsule, dividing in its course into branches, which finally break up into a plexus, the interlobular plexus, in the interlobular spaces **(Hiatt et al., 1994)**.

The spleen is situated principally in the left hypochondriac region, but its superior extremity extends into the epigastric region; it lies between the fundus of the stomach and the diaphragm. Its visceral surface is divided by a ridge into an anterior or gastric and a posterior or renal portion. Its superior extremity (*extremitas superior*) lying on the level of T11 vertebra. The posterior border (*margo posterior*), corresponds to the lower border of the 11th rib, the inferior border (*internal border*) separates the diaphragmatic from the colic surface and the lower extremity or colic surface (*extremitas inferior*) rests upon the left flexure of the colon **(Snell, 2007; Wei-Li et al., 2009; Tarantino et al., 2011)**.

The current comparative study aimed to estimate portal vein and common bile duct diameters, the length of spleen and hepatic lobes using abdominal ultrasonography and to evaluate their

relation to age, gender, weight and height of normal children younger than 18 years.

2. Subjects & Methods

The current study was conducted at Department of Anatomy, Benha University since Jan 2011 till April 2013. The study was based on extraction of data out of files of healthy children and adolescents younger than 18 years and were admitted to Surgical Departments for surgeries not related to gastrointestinal tract. Exclusion criteria included growth retardation or delay for any cause, any abdominal pathologies or congenital defects and admission for surgeries related to gastrointestinal tract.

Study participants were divided into 3 equal (n=40) age groups with equal distribution of both sexes: Group A included participants younger that 6 years, Group B included participants aged 6-12 years and those older than 12 years were included in group C. All study participants underwent anthropometric measurement and ultrasonographic examination for estimation of portal vein and common bile duct diameters, the length of right and left lobes of the liver and the length of the spleen. The relationship of demographic and anthropometric data and ultrasonographic measurements was carried out.

Anthropometric Measurements

Estimation of Height

a- Estimation of height in infancy: Crown-heel length was measured using a graduated hard wooden board on which the infants lied in a supine position with his toes pointed directly upward and his legs were fully extended by pressing down over the knees.

b- Estimation of height in childhood and adolescence: Each subject was instructed to stand upright against the stodiometer so that his heels, buttocks and scapulae were in contact with the board and his heels were fixed together. The shoulders should be relaxed as well as the arms that hung loosely at the sides. The head should be positioned on the headboard of the instrument then moved down to make contact with the vertex of the skull. The subject was then instructed to take a deep breath and stand tall. This was done to straighten out any kyphosis or lordosis. The stature was then read to the least completed unit whether from a counter or graduated scale.

Estimation of weight

a- Estimation of weight in infancy: A beam scale was used in weighing the infants. The scale placed on a table and fitted in a pan in which the infant can be comfortably placed. The scale was checked to read zero before weighing and tested for accuracy every visit by using an object of known weight. The infant was weighed in a minimum of clothing. The scale was read at the eye level.

b- Estimation of weight in childhood and adolescence: The subject was dressed in a minimum of clothing and stood straight. The weight was determined by using an accurate scale until the nearest mark below the point of overbalance was reached; this was recorded as the true weight and the scale should be regularly calibrated.

Ultrasonographic examination

Ultrasonographic examination was performed using Toshiba ultrasound machine equipped with 3.5 & 7.5 MHz curvilinear transducers in Diagnostic Radiology Department, Benha University Hospital.

a- Portal vein (PV) ultrasonography was conducted by using a right longitudinal intercostal approach **(Grant et al. 1992)**. The portal vein was visualized in its longitudinal axis at liver hilum and its greatest visible antroposterior diameter was measured **(Soyupak et al. 2009)**.

b- Common bile duct (CBD) ultrasonography: The CBD was evaluated with high resolution real time equipment. It was seen either with the subject in supine using an intercostal approach from the right or after turning the subject oblique so that the right side was raised to project the duct over the portal vein, which is used as an anatomic marker. The CBD was visualized in its longitudinal axis at liver hilum and its greatest antroposterior diameter was measured **(Bates, 2004)**.

c- Liver ultrasonography: Hepatic ultrasound is usually performed with the patient in supine position, but if it is necessary patient was rotate to the left side to promote descent of the liver below the rib cage and subject was asked to take in and hold a breath **(Gore & Levine 2000)**. The length of the left lobe was measured in a longitudinal section at the left parasternal line while the length of right lobe measured in the right anterior axillary view **(Li et al. 2004)**.

d- Splenic ultrasonography: The normal size spleen is only accessible through the intercostal spaces and complete views were obtained with the subject in the left lateral position in quite breathing and with left arm extended towards the head of the bed to open out the intercostal spaces with a pillow under the right side of the chest to improve access to the spleen **(Spielmann et al. 2005)**. To obtain the full length of the spleen, an oblique scan in

the 10th intercostal space was extended across the costal margin to the tip of the spleen **(Megremis et al. 2009)**.

Statistical analysis

Obtained data were presented as mean±SD and ranges. Results were analyzed using Wilcoxon; ranked test for unrelated data (Z-test). Possible relationships were investigated using Pearson linear regression. Sensitivity & specificity of estimated parameters as predictors were evaluated using the receiver operating characteristic (ROC) curve analysis judged by the area under the curve (AUC). Statistical analysis was conducted using the SPSS (Version 15, 2006) for Windows statistical package. P value <0.05 was considered statistically significant.

3. Results

Age and anthropometric measures of the study participants was determined and presented in table (1). There was non-significant (p>0.05) difference between males and females within each group as regards the determined demographic data.

Table (1): Age, weight and height data of study participants categorized as age-groups

		Group A	Group B	Group C
Age (years)	Males	2.8±1 (1-5)	8.2±1.7 (6-11)	14.1±1.7 (12-17)
	Females	2.9±1.2 (1-5)	8.5±1.4 (7-11)	14.4±1.6 (12-17)
	Total	2.85±1.07 (1-5)	8.35±1.5 (6-11)	14.25±1.6 (12-17)
Weight (kg)	Males	14.6±3.2 (11-20)	29.1±4.8 (21-35)	53.5±7.5 (38-62)
	Females	15.8±3.2 (12-21)	29.5±4.2 (23-39)	53.9±7.7 (44-67)
	Total	15.2±3.25 (11-21)	29.3±4.5 (21-39)	53.7±7.5 (38-67)
Height (cm)	Males	92.4±9.5 (75-109)	124.5±6.3 (116-139)	160±9.3 (145-177)
	Females	92.2±8.9 (73-105)	123.5±8.8 (108-132)	159±6 (146-165)
	Total	92.3±8.1 (73-109)	124±7.6 (108-139)	159.5±7.7 (145-177)

Data are presented as mean±SD; ranges are in parenthesis

All US measurements showed non-significant (p>0.05) difference between males and females; indicating minor gender influence on normal growth. On contrary, categorization of study population showed progressive significantly (p<0.001) higher measurements with advance of age in all obtained measurements (Table 2, Fig. 1 & 2).

Table (2): Mean diameter of PV and CBD and length of spleen and hepatic lobes estimated in studied population categorized as age-groups

			Group A	Group B	Group C
PVD (mm)	Males		0.63±0.075 (0.53-0.73)	0.79±0.05 (0.66-0.86)	0.91±0.06 (0.79-0.99)
	Females		0.64±0.088 (0.51-0.74)	0.8±0.05 (0.71-0.89)	0.89±0.1 (0.73-0.98)
	Total		0.64±0.078 (0.51-0.74)	0.79±0.05 (0.66-0.89)	0.9±0.08 (0.73-0.99)
	Statistical significance	P_1	Z=1.585, p>0.05	Z=1.069, p>0.05	Z=0.505, p>0.05
		P_2		Z=5.476, p<0.001	Z=5.515, p<0.001
		P_3			Z=4.888, p<0.001
CBDD (mm)	Males		0.18±0.04 (0.11-0.24)	0.28±0.05 (0.21-0.36)	0.37±0.06 (0.28-0.45)
	Females		0.2±0.04 (0.12-0.26)	0.26±0.04 (0.21-0.33)	0.39±0.07 (0.27-0.46)
	Total		0.19±0.04 (0.11-0.26)	0.27±0.04 (0.21-0.36)	0.38±0.06 (0.27-0.46)
	Statistical significance	P_1	Z=1.684, p>0.05	Z=0.786, p>0.05	Z=0.826, p>0.05
		P_2		Z=5.159, p<0.001	Z=5.513, p<0.001
		P_3			Z=4.292, p<0.001
Spleen	Males		7.21±0.4 (6.5-8)	8.57±0.58 (7.5-9.5)	10.34±0.94 (8.8-11.5)
	Females		7.3±0.7 (6.2-8.2)	8.63±0.55 (7.7-9.4)	10.46±0.9 (9-11.6)
	Total		7.26±0.54 (6.2-8.2)	8.63±0.54 (7.5-9.4)	10.38±0.89 (8.8-11.6)
	Statistical significance	P_1	Z=0.523, p>0.05	Z=0.483, p>0.05	Z=0.691, p>0.05
		P_2		Z=4.864, p<0.001	Z=5.581, p<0.001
		P_3			Z=4.861, p<0.001
Rt lobe	Males		7.44±0.56 (6.1-8.4)	10.1±0.65 (9.11)	11.7±0.65 (10.6-12.5)
	Females		7.37±0.71 (6.2-8.2)	10.15±0.65 (9.3-11)	11.8±0.71 (10.6-12.7)
	Total		7.38±0.63 (6.1-8.4)	10.11±0.63 (9-11)	11.8±0.66 (10.6-12.7)
	Statistical significance	P_1	Z=0.458, p>0.05	Z=0.467, p>0.05	Z=0.908, p>0.05
		P_2		Z=5.512, p<0.001	Z=5.580, p<0.001
		P_3			Z=4.941, p<0.001
Lt lobe	Males		5.68±0.54 (4.8-6.6)	7.35±0.61 (6.2-8.3)	8.65±0.47 (8-9.2)
	Females		5.9±0.45 (4.8-6.8)	7.65±0.67 (5.5-8.2)	8.81±0.4 (8.2-9.3)
	Total		5.8±0.5 (4.8-6.8)	7.48±0.65 (5.5-8.3)	8.75±0.43 (8-9.3)
	Statistical significance	P_1	Z=1.511, p>0.05	Z=1.098, p>0.05	Z=1.739, p>0.05
		P_2		Z=5.430, p<0.001	Z=5.580, p<0.001
		P_3			Z=5.164, p<0.001

Data are presented as mean±SD; ranges are in parenthesis, PVD: portal vein diameter, CBDD: common bile duct diameter, Rt. lobe: right hepatic lobe, Lt. lobe: left hepatic lobe,

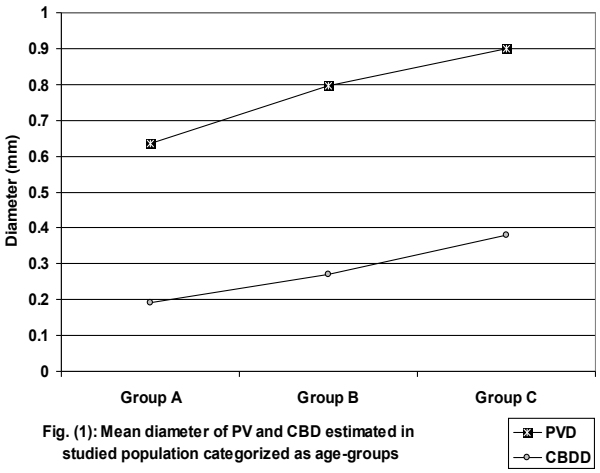


Fig. (1): Mean diameter of PV and CBD estimated in studied population categorized as age-groups

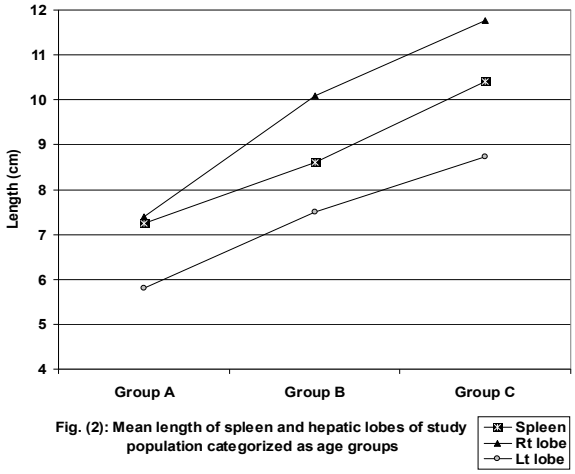


Fig. (2): Mean length of spleen and hepatic lobes of study population categorized as age groups

All obtained US measurements showed a positive significant correlation with age, weight and height. However, PVD and spleen length showed their highest correlation coefficient with height (r=0.808 & 0.861, respectively, p<0.001) while CBDD (r=0.805, p<0.001) and right and left hepatic lobes' length showed their highest correlation coefficient (r=0.892 & 0.875, respectively, p<0.001) with age, (Table 3).

Table (3): Correlation coefficient between age, weight and height and estimated US PVD, CBDD and length of spleen, left and right hepatic lobes in studied population

	Age (years)		Weight (gm)		Height (cm)	
	R	p	r	p	r	p
PVD	0.781	<0.001	0.799	<0.001	0.808	<0.001
CBDD	0.805	<0.001	0.772	<0.001	0.783	<0.001
Spleen	0.835	<0.001	0.854	<0.001	0.861	<0.001
Rt lobe	0.892	<0.001	0.866	<0.001	0.889	<0.001
Lt lobe	0.875	<0.001	0.862	<0.001	0.836	<0.001

"r": correlation coefficient, PVD: portal vein diameter, CBDD: common bile duct diameter, Rt. lobe: right hepatic lobe, Lt. lobe: left hepatic lobe

ROC curve analysis of age, weight and height as predictor for US measurements of internal organs defined height as the most specific predictor for PVD, (Fig. 3) and spleen length, (Fig. 4), with AUC= 0.697 and 0.550, respectively. On the other hand, age was the most specific predictor for CBDD, (Fig. 5) with AUC= 0.599, while weight was the most specific predictor for length of right and left hepatic lobes (Fig. 6 & 7) with AUC= 0.593 and 0.542, respectively, (Table 4).

Table (4): ROC curve analysis of the dominant predictor among age, weight and height and for estimated US PVD, CBDD and length of spleen, left and right hepatic lobes in studied population

	Age (years)		Weight (gm)		Height (cm)	
	AUC	95% CI	AUC	CI	AUC	CI
PVD	0.638	0.418-0.858	0.619	0.431-0.806	0.697	0.553-0.841
CBDD	0.599	0.463-0.734	0.579	0.369-0.789	0.595	0.440-0.750
Spleen	0.490	0.331-0.648	0.517	0.385-0.650	0.550	0.354-0.747
Rt. lobe	0.543	0.410-0.676	0.593	0.476-0.709	0.480	0.338-0.622
Lt lobe	0.509	0.395-0.623	0.542	0.435-0.650	0.433	0.320-0.546

AUC: Area under curve, CI: confidence interval, PVD: portal vein diameter, CBDD: common bile duct diameter, Rt. lobe: right hepatic lobe, Lt. lobe: left hepatic lobe

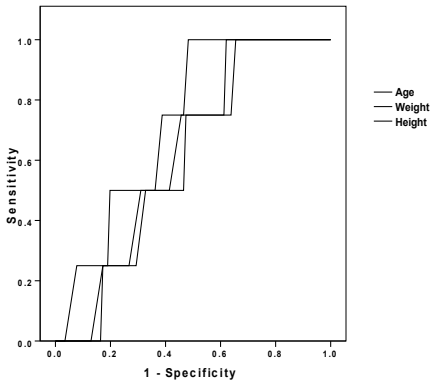


Fig. (3): ROC curve analysis for age, weight and height as predictors for US measurement of PVD

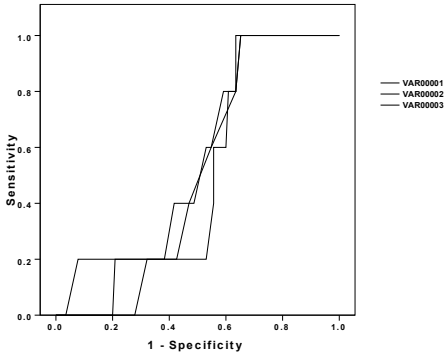


Fig. (4): ROC curve analysis for age, weight and height as predictors for US measurement of length of spleen

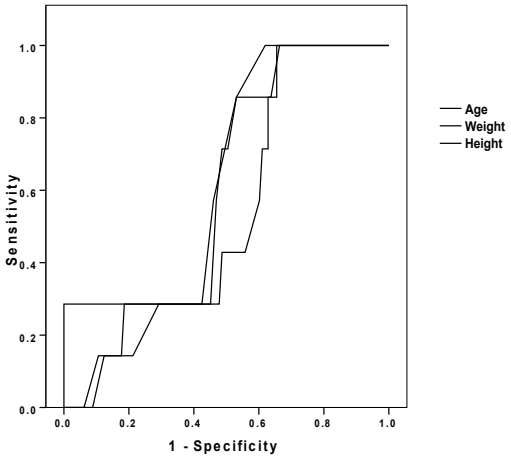


Fig. (5): ROC curve analysis for age, weight and height as predictors for US measurement of CBDD

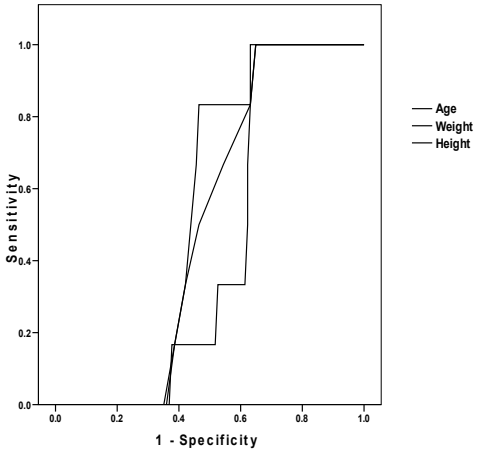


Fig. (6): ROC curve analysis for age, weight and height as predictors for US measurement of length of left lobe of liver

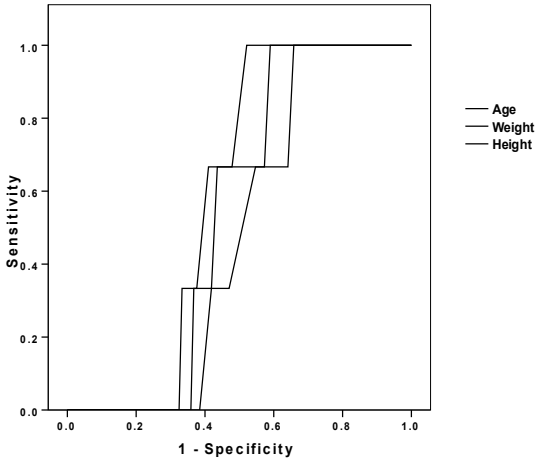
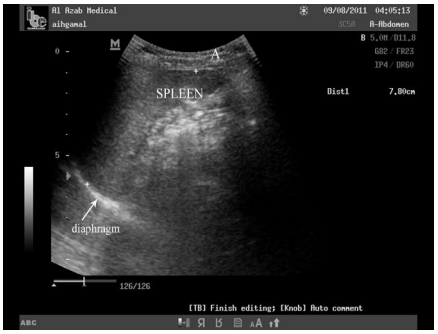


Fig. (7): ROC curve analysis for age, weight and height as predictors for US measurement of length of right lobe of liver

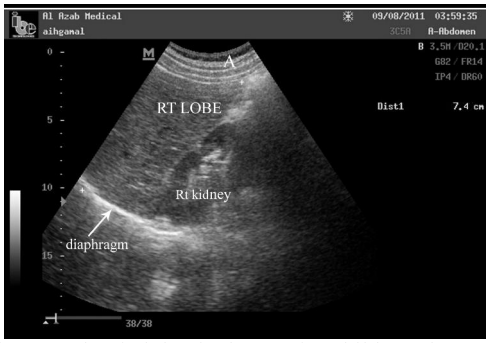
Case presentation

A case of child aged 3.5 years representing Group A subjects

A photograph of abdominal US of a child aged 3.5 years (Group A) showing diameter of portal vein (PV) and common bile duct (CBD) at the porta hepatis. (A: Anterior abdominal wall).



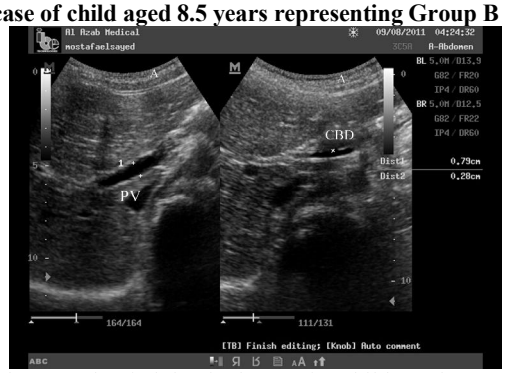
A photograph of abdominal US of a child aged 3.5 years (Group A) showing the spleen measuring 7.8 cm length. (A: Anterior abdominal wall).



A photograph of abdominal US of a child aged 3.5 years (Group A) showing the Rt. lobe of the liver measuring 7.4 cm length. (RT= Right, A: Anterior abdominal wall).

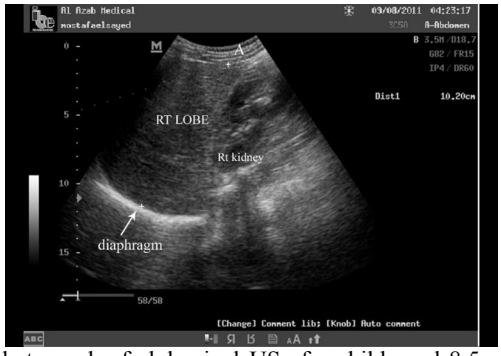
A photograph of abdominal US of a child aged 3.5 years (Group A) showing the Lt lobe of the liver measuring 6.13 cm length. (LT: Left, A: Anterior abdominal wall).

A case of child aged 8.5 years representing Group B subjects



A photograph of abdominal US of a child aged 8.5 years (Group B) showing diameter of portal vein (PV) and common bile duct (CBD) at the porta hepatis. (A: Anterior abdominal wall).

A photograph of abdominal US of a child aged 8.5 years (Group B) showing the spleen measuring 9.06 cm length. (A: Anterior abdominal wall).

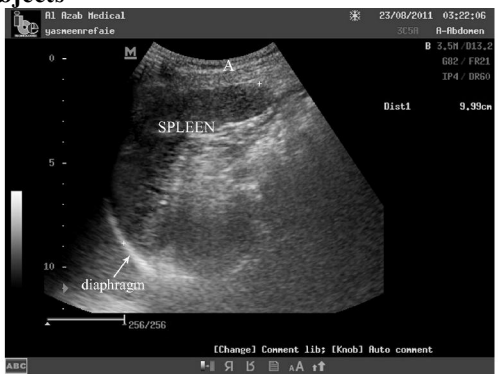


A photograph of abdominal US of a child aged 8.5 years (Group B) showing the Rt. lobe of the liver measuring 10.2 cm length. (RT= Right, A: Anterior abdominal wall).

A photograph of abdominal US of a child aged 8.5 years (Group B) showing the Lt lobe of the liver measuring 7.4 cm length. (Anterior abdominal wall: A).

A case of child aged 15 years representing Group C subjects

A photograph of abdominal US of a child aged 15 years (Group C) showing diameter of portal vein (PV) and common bile duct (CBD) at the porta hepatis. (A: Anterior abdominal wall).



A photograph of abdominal US of a child aged 15 years (Group C) showing the spleen measuring 9.99 cm length. (A: Anterior abdominal wall).

A photograph of abdominal US of an adolescent aged 15 years (Group C) showing the Rt. lobe of the liver measuring 11.7 cm length. (RT: right, A: Anterior abdominal wall).

A photograph of abdominal US of an adolescent aged 15 years (Group C) showing the Lt lobe of the liver measuring 8.58 cm length. (LT: Left, A: Anterior abdominal wall).

4. Discussion

The current study relied on screening for normal measurements of hepatic lobes, spleen, CBD and PV among normal healthy children and adolescents younger than 18 years so as to determine the impact of progress of age, weight and height on these normal measurements to be used as reference to evaluate the pathological changes on examination of diseased personnel of the same age group. In line with this target; **Sienz et al. (2011)** using abdominal US tried determination of reference values gallbladder, gallbladder wall, bile ducts, pancreas and the spleen

in normal subjects older than 18 years and concluded that normal values are helpful in delimiting numerous pathological changes in the respective organs. Also, **Otiv et al. (2012)** tried to determine the renal size in normal Indian children by abdominal US and found a strong correlation between renal size and various somatic parameters, but the best correlation was between renal length and body height.

There was non-significant difference in estimated parameters between males and females; a finding indicated that no impact of sex on the natural growth process manifested as these measurements. In line with this finding; **Safak et al. (2005)** found no significant differences in organ dimensions with respect to sex. **Admassie (2008)** showed that there was no significant difference between the two sexes and CBDD.

The current study reported significant differences of measurements of portal vein diameter (PVD) and common bile duct diameters (CBDD) and lengths of spleen and both hepatic lobes between age groups. Moreover, there was a positive significant correlation between age, weight and height on one-side and all evaluated measurements on the other side. ROC curve analysis illustrates a variable effect of these factors on the evaluated measurements; where age showed the highest effect on CBDD, weight showed the highest effect on length of hepatic lobes and height showed the highest effect on PVD and length of spleen.

These data go in hand with **Konuş et al. (1998)** found that determination of pathologic changes in size of the liver, spleen, and kidney necessitates knowing the normal range of dimensions for these organs in healthy neonates, infants, and children. **Capaccioli et al. (2000)** reported a good correlation between age and dimensions for pancreas, kidneys and spleen in children, representing the progressive growth of these organs. **Megremis et al. (2004)** also, found age, height, and either weight or BSA had significant positive associations with spleen length. **Admassie (2008)** showed that there was a positive correlation between CBDD and weight with no association was observed with height.

Balcha & Admassi (2012) found that in children younger than 13 years, the mean of liver size on mid clavicular line and mid-sternal line had statistically significant correlation with age, height and weight, with strong correlation with height. **Kahramaner et al. (2013)** also, reported that longitudinal and anteroposterior dimensions of the liver and spleen showed high correlation with the gestational age, weight and height.

In line with the specificity of height as the significant determinant for PVD and length of spleen; **Konuş et al. (1998)** found that body height should be considered the best criteria to correlate with longitudinal dimensions of liver, spleen, and kidney. **Chowdhury et al., (2009)** indicated that length of the spleen increases with height of the individual, but also the length of the spleen depends on the age and body height of the individual. **Soyupak et al. (2009)** added that there is a progressive increase in PVD in relation to age, height and weight. **Dhingra et al. (2010)** found that liver and spleen length significantly correlated with the height/length in healthy Indian children the subjects

It could be concluded that US assessment of the normal dimensions of studied organs could be a useful tool to discriminate pathologically enlarged or reduced organs. Despite age was found to be the main determinant of growth rate of these organs, body height was the most significant determinant for PVD and splenic length, while weight was the most significant determinant of CBDD and hepatic length.

References

1. Admassie D: Ultrasound assessment of common bile duct diameter in Tikur Anbessa Hospital, Addis Ababa, Ethiopia. Ethiop Med J. 2008; 46(4):391-5.
2. Balcha HH, Admassi D: Normal liver size measurement in Ethiopian children below thirteen years of age, Black Lion Hospital, Addis Ababa, Ethiopia. Ethiop Med J. 2012;50(2):153-8.
3. Bates JA: Abdominal Ultrasound: How, Why and When, 2nd ed., Churchil Livingstone, Edinburgh, London, New York, 2004; Pp: 17-33.
4. Capaccioli L, Stecco A, Vanzi E, Brizzi E: Ultrasonographic study on the growth and dimensions of healthy children and adults organs. Ital J Anat Embryol. 2000; 105(1):1-50.
5. Castaing D: Surgical anatomy of the biliary tract. Hepato-Pancreatico-Biliary (Oxford), 2008; 10(2): 72-6.
6. Chaib E, Ribeiro MA Jr, Saad WA, Gama-Rodrigues J: The main hepatic anatomic variations for the purpose of split-liver transplantation. Transplant Proc. 2005; 37(2):1063-6.
7. Chaib E, Bertevello P, Saad WA, Pinotti HW, Gama-Rodrigues J: The main hepatic anatomic variations for the purpose of split-liver transplantation. Hepatogastroenterology. 2007;54(75):688-92.
8. Chaib E, Kanas AF, Galvão FH, D'Albuquerque LA: Bile duct confluence: anatomic variations and its classification. Surg Radiol Anat. 2013; Epub ahead of print.
9. Chowdhury AI, Khalil M, Begum JA, Rahman MH, Mannan S, Sultana SZ, Rahman MM,

Ahamed MS, Sultana ZR: Gross anatomical study of spleenic length. Mymensingh Med J. 2009; 18(1 Suppl):S34-39.
10. Dhingra B, Sharma S, Mishra D, Kumari R, Pandey RM, Aggarwal S: Normal values of liver and spleen size by ultrasonography in Indian children. Indian Pediatr. 2010;47(6):487-92.
11. Gore RM, Levine MS: Textbook of Gastrointestinal Ultrasonography, 2nd ed., Philadelphia: Saunders Co., 2000; Pp: 1487-97.
12. Grant EG, Schiller LK, Millener P: Color Doppler imaging of the hepatic vasculature. AJR, 1992; 159: 943-50.
13. Hiatt JR, Gabbay J, Busuttil RW: Surgical anatomy of the hepatic arteries in 1000 cases. Ann Surg. 1994; 220(1):50-2.
14. Kahramaner Z, Erdemir A, Cicek E, Cosar H, Turkoglu E, Sutcuoglu S, Ozer EA: Reference ranges for sonographic dimensions of the liver and spleen in preterm infants. Pediatr Radiol. 2013, Epub ahead of print
15. Konuş OL, Ozdemir A, Akkaya A, Erbaş G, Celik H, Işik S: Normal liver, spleen, and kidney dimensions in neonates, infants, and children: evaluation with sonography. AJR Am J Roentgenol. 1998;171(6):1693-8.
16. Li YS, Kardorff R, Richter J, Sun KY, Zhou H, McManus DP, Hatz C: Ultrasound organometry: the importance of body height adjusted normal ranges in assessing liver and spleen parameters. Acta Tropica, 2004; 92:133-8.
17. Megremis SD, Vlachonikolis IG, Tsilimigaki AM: Spleen length in childhood with ultrasound. Radiology, 2004; 231: 129-34.
18. Otiv A, Mehta K, Ali U, Nadkarni M: Sonographic measurement of renal size in normal Indian children. Indian Pediatr. 2012; 49(7):533-6.
19. Safak AA, Simsek E, Bahcebasi T: Sonographic assessment of the normal limits and percentile curves of liver, spleen, and kidney dimensions in healthy school-aged children. J Ultrasound Med. 2005; 24(10):1359-64.
20. Sienz M, Ignee A, Dietrich CF: Reference values in abdominal ultrasound - biliopancreatic system and spleen. Z Gastroenterol. 2011; 49(7):845-70.
21. Snell RS. Chapter 5: The abdomen: part II. The abdominal cavity. Clinical Anatomy by Regions. 8th ed. Baltimore, Md: Lippincott, Williams & Wilkins; 2007:259-60.
22. Soyupak S, Aylin G, Gulsah S, Figen B, Medih C, Mehmet I: Portal Venous diameter in children: Normal limits according to age,weight and height. Radiology, 2009; 245-7.
23. Spielmann AL, Delong DM, Kliewer MA: Sonographic evaluation of spleen size in tall healthy athletes. AJR, 2005; 184: 45-9.
24. Strong RW, Fawcett J, Hatzifotis M, Hodgkinson P, Lynch S, O'Rourke T, Slater K, Yeung S: Surgical implications of a left-sided gallbladder. Am J Surg. 2013; 206(1):59-63.
25. Tarantino G, Savastano S, Capone D, Colao A: Spleen: A new role for an old player? World J Gastroenterol. 2011; 17(33): 3776–3784.
26. Wei-Li Xu, Suo-Lin Li, Yan Wang, Meng Li, Ai-Guo Niu: Role of color Doppler flow imaging in applicable anatomy of spleen vessels. World J Gastroenterol. 2009; 15(5): 607–611.

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